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A Touch of the Future: Contact-Expressive Devices

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Imagine the following scenario: Karo moves into the living room to find Janet lounging on the sofa with her infant son, Paul, sleeping beside her. Young Paul moves in his sleep so Karo crawls up and sprawls next to him. Janet pats Karo affectionately on the head and Paul opens his eyes. Janet then pats Paul on the head, too. Paul smiles sleepily at the joke, wraps one arm around Karo, and snuggles into the soft warmth. Karo and Paul start to breathe deeply and evenly.

A little later Karo indicates that Janet's friend John is calling and that John's in the mood for a long chat; Janet decides not to answer. Karo puts his nose under Janet's arm, nudging it up a few times until she gets the idea that he wants to be stroked. Karo settles his head into her lap. When Karo's head begins to get too heavy, Janet tries to push it off. Karo then notices that he would disturb the sleeping baby if he moved in the direction she's pushing, so he resists. When Janet stops pushing, he moves his head in a different direction.

After a while, Janet drifts off to sleep—and awakens when the nearly empty bowl of chips beside her slides off the sofa and spills onto the carpet. She reaches out her hand to confirm that Karo is still lying beside her, then pats and pushes him to indicate that he should take care of it; he responds by getting up, eating the spilled chips, picking up the bowl in his mouth, and taking it into the kitchen.

For the most part, it was probably easy to visualize the scenario. The silent use of physical contact to communicate with pets and people is so much a part of our daily lives that we're often unaware of how frequent and expressive it is.

The scenario suggests some ways in which contact-expressive devices could improve our lives—from practical improvements that let us interact with devices when other modalities are impossible, inappropriate, or inadequate to devices that have important consequences for physical well being. We can also imagine using contact expressions in devices that are pleasurable, playful, artistic, or otherwise important to a human's experience.

It's likely that we could see this scenario in the near future. Karo could be a robotic device, and all of the activity could take place silently in the dark. When reexamining the scenario in terms of a contact-expressive device, two issues arise:

- What are the technical requirements for such devices?
- What do we need to know about the nature of contact expressions?

In the following sections, I'll briefly look at these issues in terms of their current status and the work that still needs to occur. I'll focus on the technical development of sensor-motor systems, tactile interfaces, and technologies that can embody and understand affect.

A grip on contact expressions

What do I mean by contact-expressive devices? Briefly, they're technologies that understand and use touch in meaningful ways—that can distinguish between a press and a caress.

Although a fairly large body of research exists regarding nonverbal communication, the majority of this work is on visual expression (facial expressions, physical appearance, direction of gaze, physical posture, and other visible forms of body language) and paralinguistics (such as vocal inflection, pitch, volume, and speech rate). To a certain extent, the existing attempts to describe or analyze human contact tend to be attempts to create general descriptive taxonomies. Although these may ultimately prove useful, it isn't clear how much they will help for the specific require-

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ments of developing contact-expressive devices. To take just one example, consider the physical contact joke suggested in the opening scenario; there's very little research on this category of contact pretend play. The current state of research on these and other contact phenomena doesn't seem well developed enough yet to provide the kind of assistance necessary in developing devices able to respond to such jokes.

Of course, studies exist regarding the therapeutic importance of human touch (for example, the classic studies by Harlow on surrogate mothers).[1] These studies tend to confirm the importance of including contact expressions in different kinds of devices. However, so far they haven't given us much insight into what, when, or how.

Similarly, there are few relevant results from semiotics, a discipline concerned with the full range of signification (or meaning making). Indeed, physical contact is one of the areas that seems least explored by semioticians. To be sure, it's mentioned (usually in a cursory manner) as part of the larger field of semiotics, but there seems to be very little detailed study, theory, or discussion about the signifying nature of physical contact.

A fair amount of work exists on developing semiotic models of imagery, and some of this in turn has been further developed to help designers of visual interfaces. Still, we have yet to see the same level of work on understanding contact expressions and applying those insights for interface design.

Advances in tactile interfaces

In the opening scenario, Karo was able to coordinate various kinds of sensory input with different appropriate movements.

Of course, a number of efforts exist to develop technologies that accept tactile (or haptic) input and, to a lesser degree, provide tactile output (such as force feedback). Most of the work to develop tactile interfaces has concentrated on mapping different aspects of the physical world within simulated environments (such as game force-feedback devices, motion simulators, the movement of an on-screen pen over physical contours of a virtual surface, and so on)—and on providing additional feedback in multimodal systems for complex tasks (such as force feedback for molecular docking systems). Similarly, researchers are developing handheld devices with ambient touch interfaces that can support different physical interactions such as tilting, dropping, spinning, rubbing the device against something else, and so on. It's not much of an oversimplification, however, to say that developing responsive haptic technologies has, to date, been largely an effort to develop "do what I press" interfaces—and "press upon me what I see (or can't see)" feedback devices.

Developing successful contact-expressive devices is going to require more sophisticated and subtle techniques and insights

I'm not criticizing these efforts: they're important and present difficult challenges. However, developing successful contact-expressive devices is going to require more sophisticated and subtle techniques and insights into "do what my caress means"—as well as "contact-express what you mean."

An early precursor to such work on tactile conviviality was in the development of Noobie, the furry computer.[2] It was a computer in the form of an oversized, plush toy for small children to climb on, snuggle into, and sit (or lay) on. Numerous researchers have elaborated on the theme of using plush toys to make the interface friendly and familiar with children's toys. However, very few projects seem to elaborate on the contact-expressive potential of the original Noobie project.

In terms of Karo's movement, during the last few years we've seen numerous advances in robotics. There are now fairly sophisticated robotic vacuum cleaners (Roomba, Trilobite, and so on), robot soccer players in the RoboCup competitions, and even humanoid robots with remarkable mobility, articulation, and balance (from Sony and Honda, among others). Also, a number of projects around the world focus on developing robots for health care. Many of these projects are motivated by the coming crisis in health and elderly care, and tend to focus on many practical issues such as medicine delivery, the cleaning of bed pans, and the like. However, there are also a few—such as those led by

Web Resources

I've collected a number of Web resources that might help you get further information about contact-expressive devices.

Studying physical contact

International Society for Haptics: http://www.isfh.org/
Haptics-e Journal: http://www.haptics-e.org/

Advances in tactile interfaces

Takanori Shibata: http://www.itp.net/features/102327432190564.htm
MIT Tangible Media Group: http://tangible.media.mit.edu/
"Promise of Touch Technologies," *BBC News*, 14 Nov. 2001, http://news.bbc.co.uk/1/hi/sci/tech/1646909.stm
D. Marculescu et al., "Ready to Ware," *IEEE Spectrum,* 11 Nov. 2003, http://www.spectrum.ieee.org/WEBONLY/publicfeature/oct03/ware.html

Affective technologies

Affective Technologies: http://affect.media.mit.edu/
Affective Computing Portal: http://www.bartneck.de/link/affective_portal.html

Contact-expressive technologies

PilloMate: http://www.cs.chalmers.se/idc/ituniv/student/2002/ubicomp/grupp2/
Blanket Project: http://www.nickstedman.com/blanket.html
Tickle Salon: http://www.xs4all.nl/~notnot/TickleSalon/TickleSalon.html

Takanori Shibata, senior research scientist for Japan's National Institute of Advanced Industrial Science and Technology—that are developing robotic devices that can also address some of the physical contact needs of patients.

Affective technologies

In the opening scenario, Karo was able to communicate the identity and the mood of the caller. In some ways, this kind of thing is trivial even today. We all use cell phones that have different means of identifying the caller, and knowing what mood a caller is in could be handled by having a caller indicate it (much as people use emoticons to indicate their mood when they send email). However, more sophisticated solutions are being developed in the realm of affective computing, and research in this area is making substantial progress in identifying the mood of others as well as in developing technologies that people accept as "having" emotional states. This is obviously a difficult—and controversial—research area, but it seems promising in terms of some of the capabilities we would want for a device such as Karo.

Finally, one related aspect of Karo's physical behavior might have seemed odd or unnecessary: the attempt to have Janet pet him. In addition to the human needs this may fulfill, it may also be of great practical value to include mechanisms such as this for recharging the device's batteries. In recent years we have seen innovative solutions, such as wind-up mechanisms, proposed for powering computational devices. In a similar vein, it would be interesting to explore the possibility of using physical contact to generate or supplement a device's power requirements.

Making contact expressive

In addition to the work already mentioned, some different examples already suggest the promise of future contact-expressive devices.

A group of graduate students at the Information Technology University in Gothenburg, Sweden, developed a PilloMate pillow device that embodies some of the contact-expressive input/ouput characteristics of a cat. It can respond to different kinds of stroking, pressure, and heat—and it responds with different combinations of vibrations, heat, and so on. The pillow is also a nice example of the kind of work that will support the study of the meaning making that people do—the pillow doesn't explicitly confirm whether people have interpreted it correctly; it simply responds to, and initiates, contact expressions. Some of these expressions have been given a particular semantic meaning by the designers—but others are assigned by the users.[3]

Artists are also creating contact-expressive installations and events. For example, the artist Nick Stedman has created *The Blanket Project*, in which a soft blanket with embedded electronics and computation can move and physically interact with people. And in Holland, artists created the *Tickle Salon* as an installation with a semiautonomous tickling robot.

Finally, one of the most interesting possibilities was actually suggested by a graduate student of mine who has Tourette's Syndrome. Indeed, it was she who made me aware of the importance of contact-expressive devices. Based on the insight that online interaction is often less inhibited, the student wanted to do a robot project for autistic children. Her long-term hope for contact-expressive robots is that they may provide acceptable contact opportunities for future gen-

erations of children who confront some of the challenges she does.

The final touch

In many ways, we can already see certain aspects of the future trajectory of contact-expressive devices—in the combination of personalized ring tones and the use of vibration signals on today's mobile phones. Future developments of telephones (and other devices) will increase these contact-expressive capabilities.

Historically, we're at the point where it's reasonable to start looking at how to leverage studies of human touch, semiotic analysis, human interface design, and sensor-motor technologies to increase the expressive capabilities of the devices we build. It's really only now, when the technical potential is reasonably close, that it makes sense to address the technical issues of contact expressions and the new challenges that arise for cognitive studies (and user interface design) as we become interested in the application of insights from each domain back to the other. In other words, work needs to begin on studies of human contact with the goal of leveraging those insights for the design of contact-expressive devices—and work needs to begin on the implementation of technologies that have rich contact-expressive range and appeal. **MM**

References

1. H. Harlow, "The Nature of Love," *Am. Psychologist*, vol. 13, 1958, pp. 573-685.
2. A. Druin, "NOOBIE: The Animal Design Playstation," *ACM Computer–Human Interaction Bulletin*, ACM Press, vol. 20, no. 1, 1988, pp. 45-53.
3. K. McGee and A. Harup, "Contact Expressions for Touching Technologies," *Proc. 3rd Conf. Computational Semiotics in Games and New Media*, 2003, pp. 68-76.

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